

# Fab Inc.

## Part Processing / 3D Model Classification



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# Business Problem

**Reduce engineering time and error** in order to  
assign the manufacturing process for individual parts  
at Fab Inc.

# Business Problem



Reduce time

8 hours per month



Reduce human error

7%

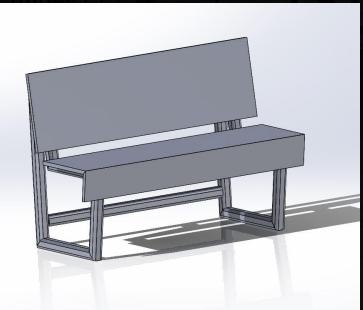
# Business Problem



# Project objective

To develop a **Convolutional Neural Network** that can properly identify the required processes for each 3D modeled part.

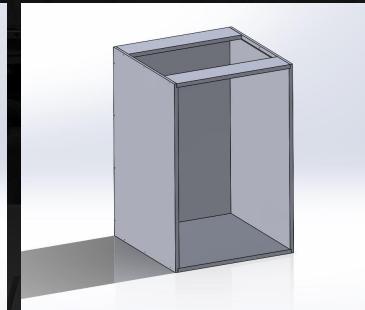
# Data



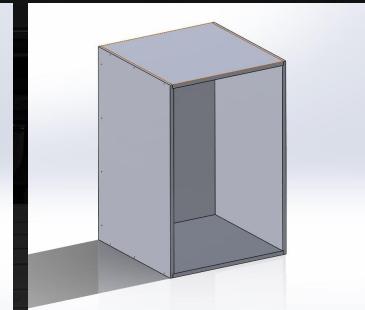
**Bench1**  
4 parts  
16 configurations



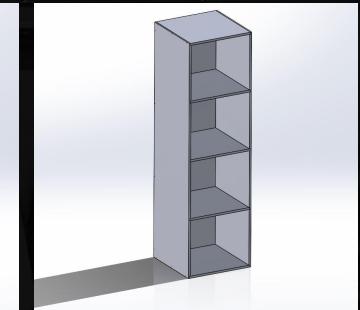
**Bench2**  
3 parts  
21 configurations



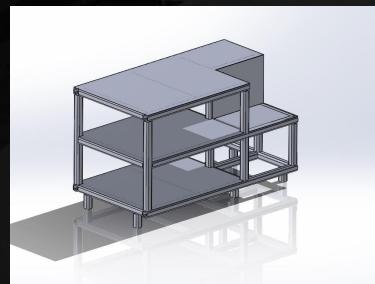
**Cab1**  
6 parts  
8 configurations



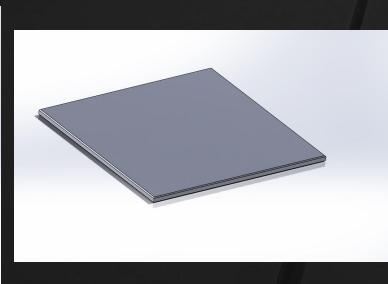
**Cab2**  
5 parts  
32 configurations



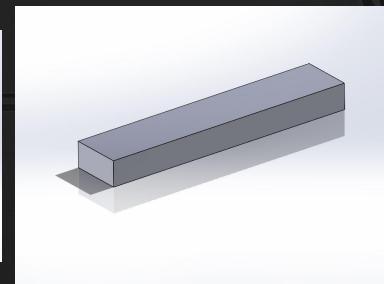
**Cab3**  
6 parts  
28 configurations



**Counter1**  
5 parts  
15 configurations



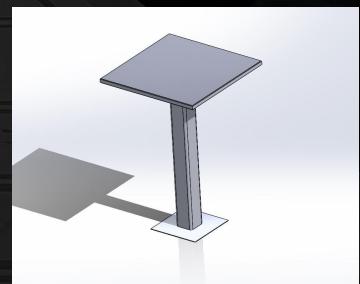
**Shelf1**  
1 part  
96 configurations



**Shelf2**  
6 parts  
14 configurations



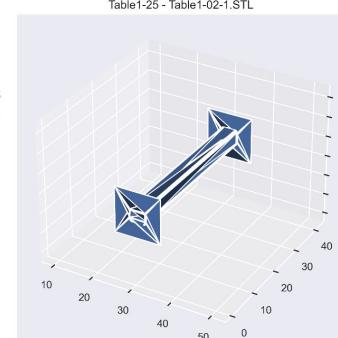
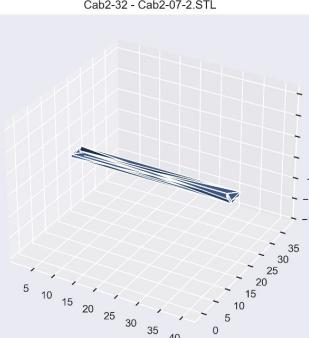
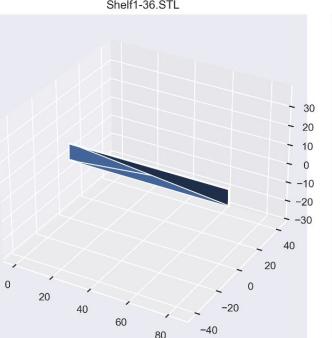
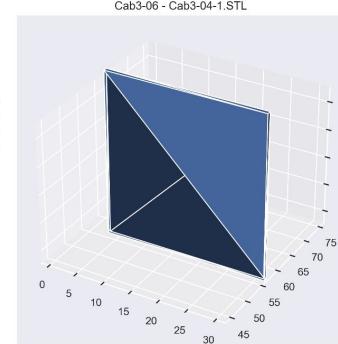
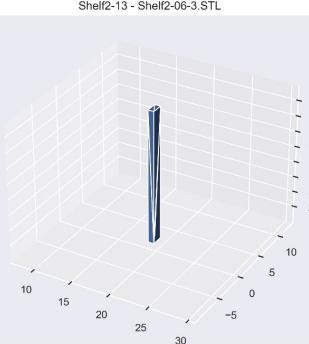
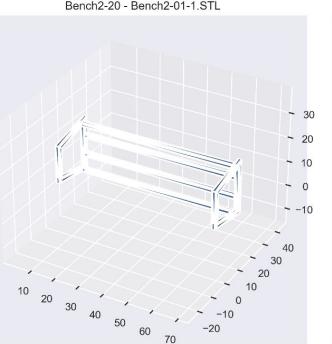
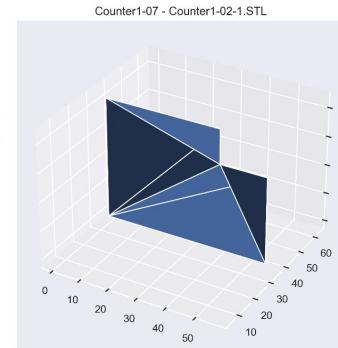
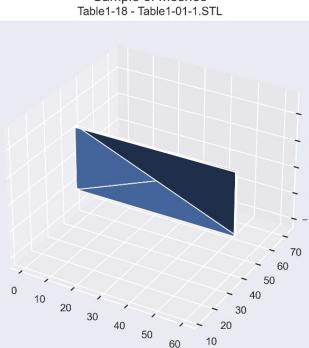
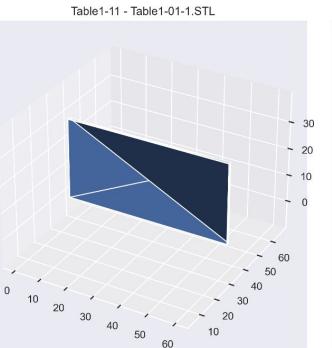
**Station1**  
2 parts  
18 configurations



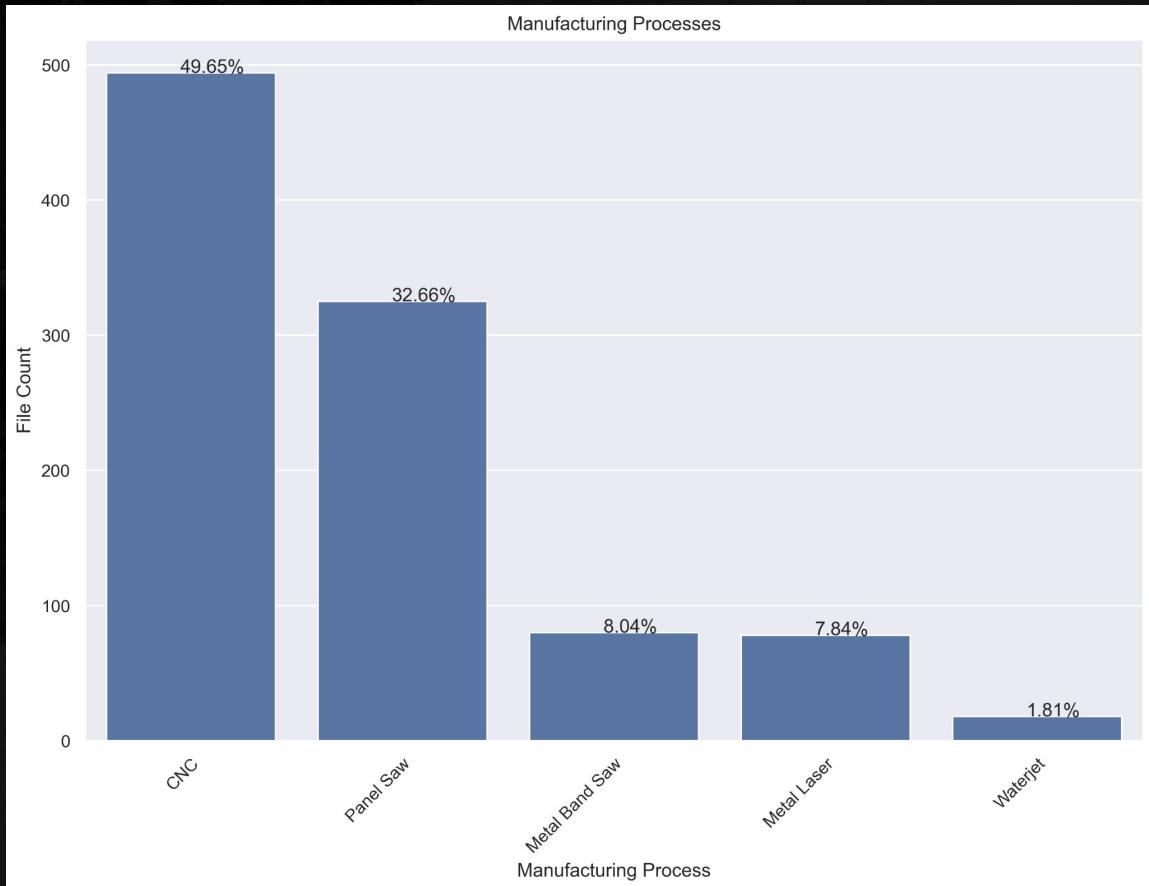
**Table1**  
2 parts  
28 configurations

# Data Collection

- 995 parts in total
- Human identified class of cutting manufacturing process



# Data



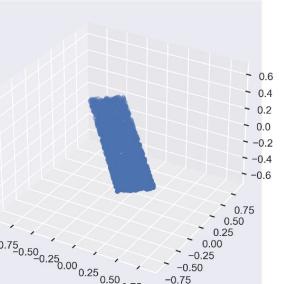
- CNC and Panel Saw are the most common processes used at the machine to cut material

# Data - Correct

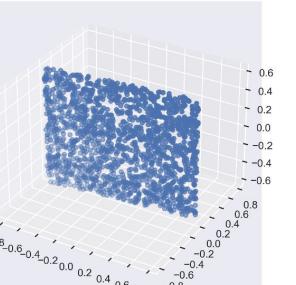
Correct pointclouds show metal weldments and flat panels

Classes Number Legend  
0 = CNC  
1 = Metal Band Saw  
2 = Metal Laser  
3 = Panel Saw  
4 = Waterjet

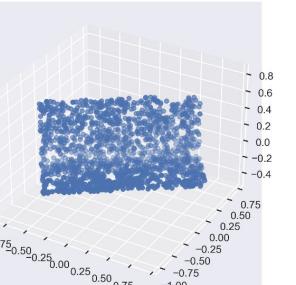
Predicted Class 3  
Class Probabilities  
[-0.9683 -3.6284 -3.3594 -0.6381 -3.4846]  
Actual Class 3



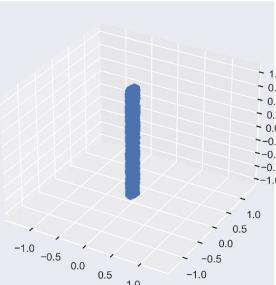
Predicted Class 0  
Class Probabilities  
[-0.8536 -2.1434 -1.1861 -2.144 -3.3737]  
Actual Class 0



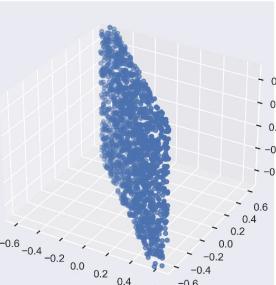
Predicted Class 2  
Class Probabilities  
[-2.4921 -2.6559 -0.3399 -3.2471 -2.3402]  
Actual Class 2



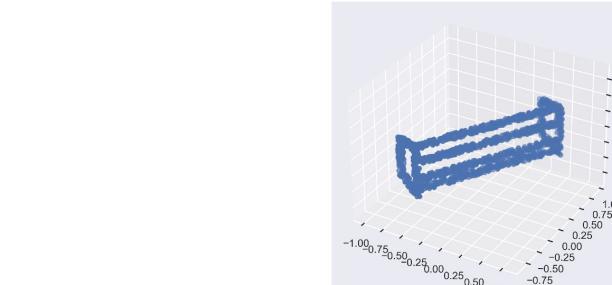
Predicted Class 3  
Class Probabilities  
[-1.0563 -4.0111 -3.8781 -0.5277 -3.7512]  
Actual Class 3



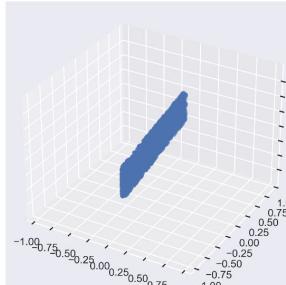
Predicted Class 0  
Class Probabilities  
[-0.9204 -1.9969 -1.2859 -1.9608 -3.0208]  
Actual Class 0



Predicted Class 1  
Class Probabilities  
[-2.6494 -0.6508 -2.0591 -2.0312 -1.9042]  
Actual Class 1



Predicted Class 3  
Class Probabilities  
[-1.0071 -2.8962 -3.0585 -0.73 -2.984]  
Actual Class 3



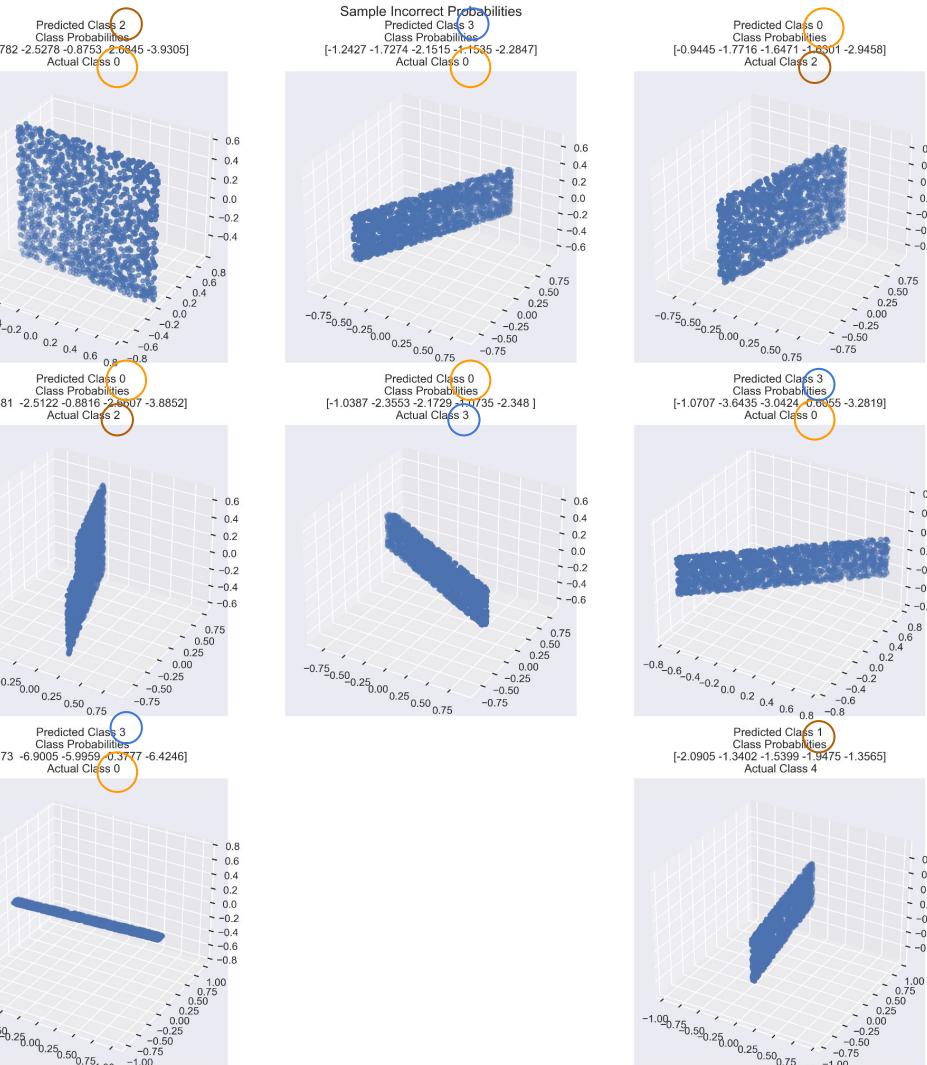
# Data - Incorrect

Incorrect mesh pointclouds show varied issues to be dealt with:

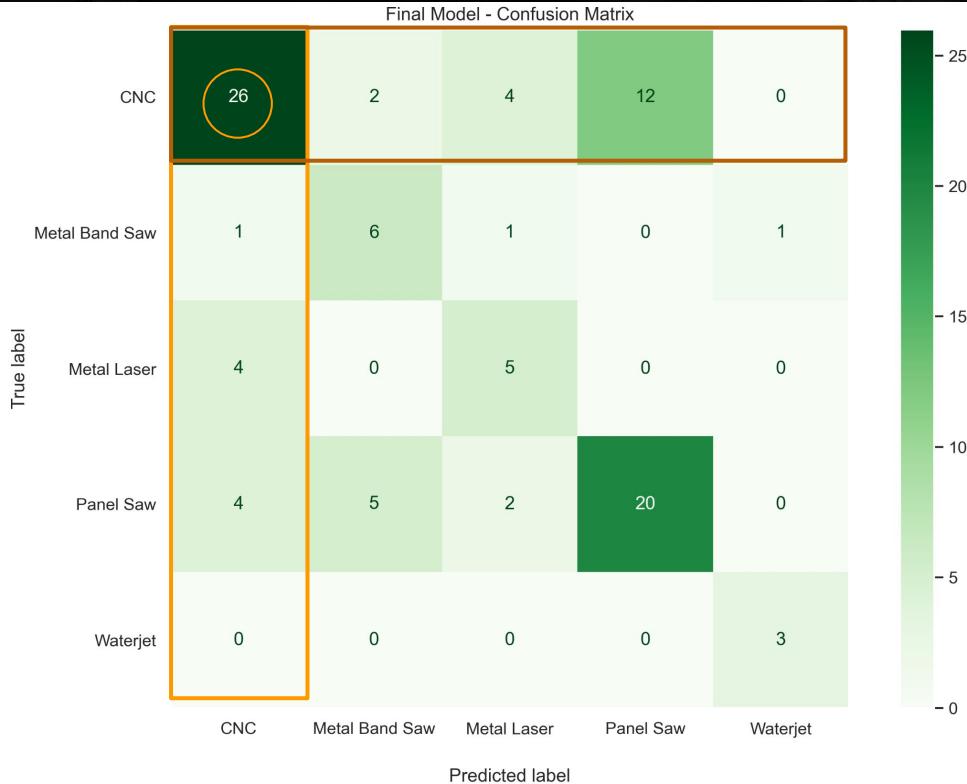
Most mispredictions in CNC (0) class

Material feature integrated into model would fix mispredictions with Metal Laser (2) and Metal Band Saw (1)

The mesh faces integrated into a different model architecture would fix mispredictions with Panel Saw (3)



# Results



## Metrics

Total of 96 items in test set

# Recommendations - Implementation



**Model** can be **implemented** for designating CNC processes with engineering supervision

**Human assignment** should happen for **all items identified as not CNC** by the algorithm.

**Manual assignment** to the **CNC class** needs to be **triple checked**

An **assignment flow diagram** should be given to an **administrative member to handle assignments**

Model shall be **improved over a 90 day period**, after which full deployment for all 5 classes would be possible.

# Next Steps

1

**Increase** amount of **data** to train on by using 10,000 or 20,000 3D models

2

**Gather more accurate measurements on machine time** from the factory rather than provided estimates

3

**Better accuracy** could be obtained by **utilizing other types of neural network architectures** (not only analyzing pointclouds)

4

**Integrate materials** into the modeling

5

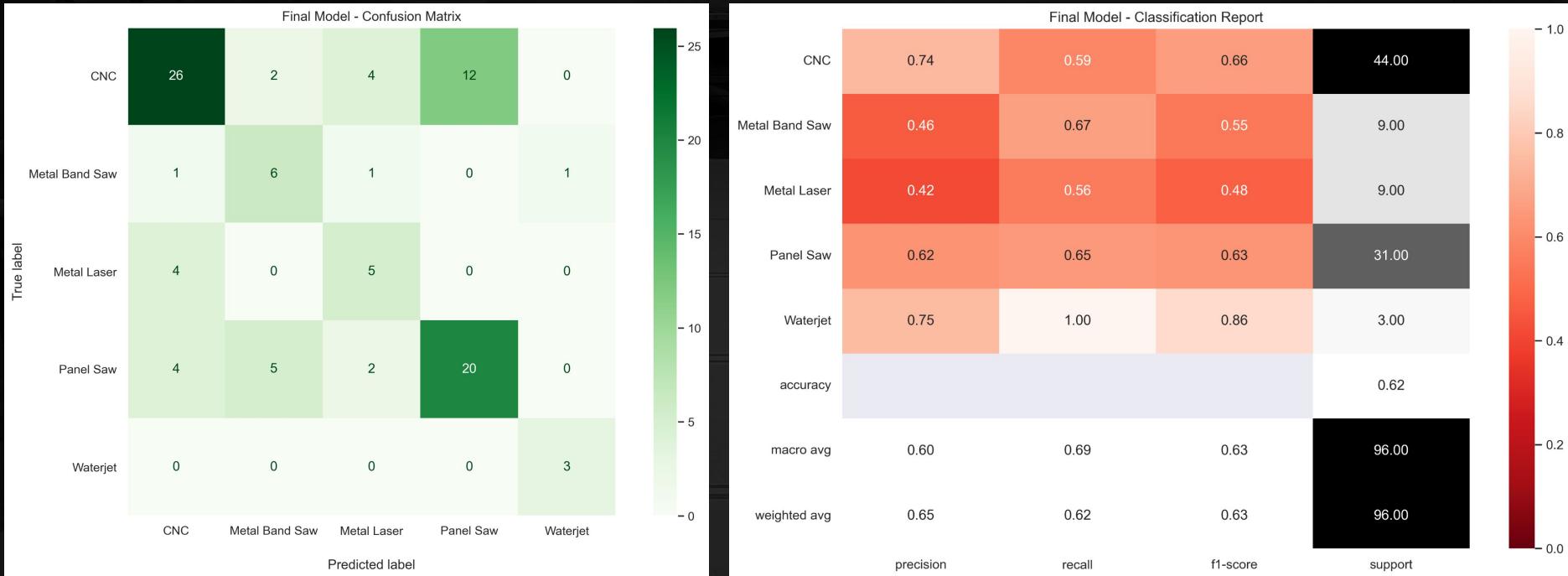
**Gather more accurate measurements for material square footage** from the models rather provided estimates



THANK YOU

# APPENDIX

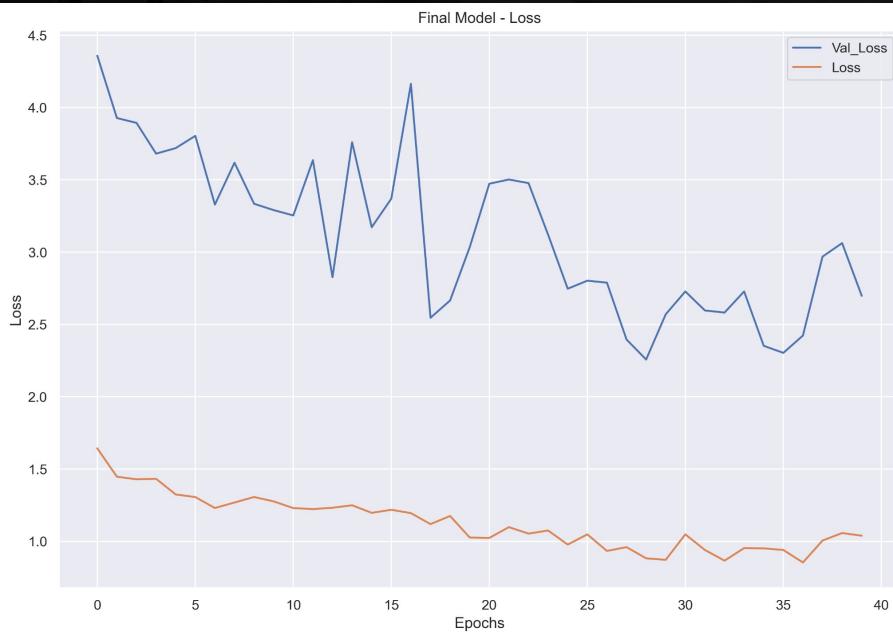
# Data - Final Model



Precision for CNC is perfect

High values overall metrics  
without data augmentation

# Data - Final Model



Loss improving over time



Accuracy improving over time

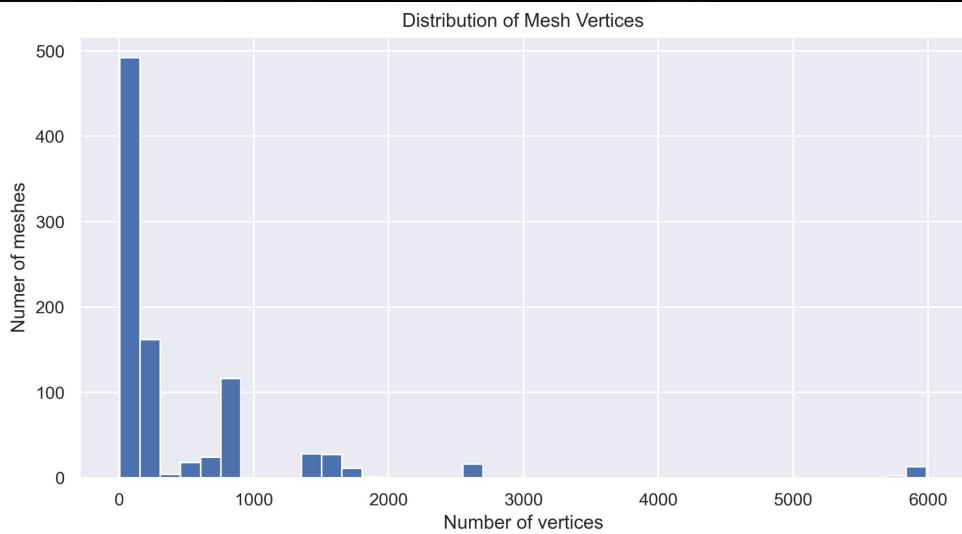
# Data - Time Material Cost



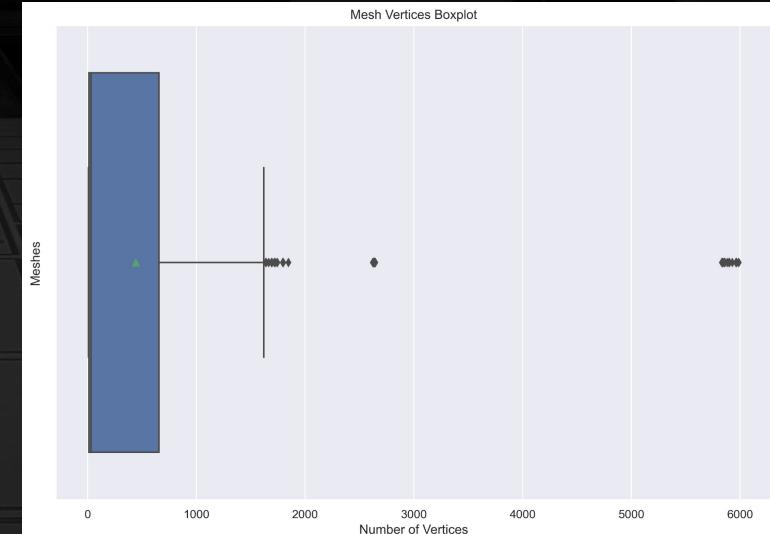
CNC highest time cost

TFL highest spending  
CNC highest material cost

# Data - Mesh Vertices



Wide variance in mesh vertices



Outliers at 6000 and 2600  
vertices

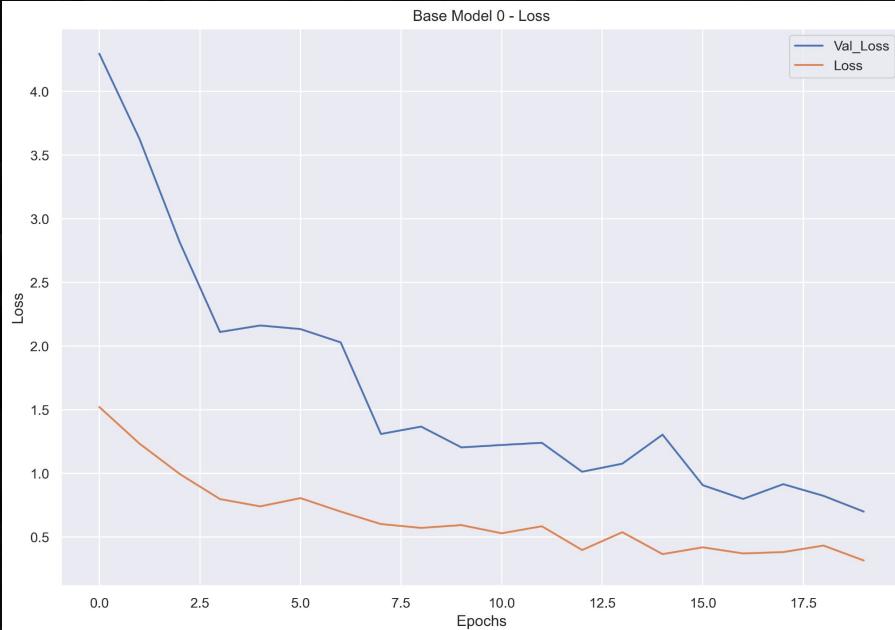
# Data - Base Model



Precision for CNC is perfect

High values overall metrics  
without data augmentation

# Data - Base Model

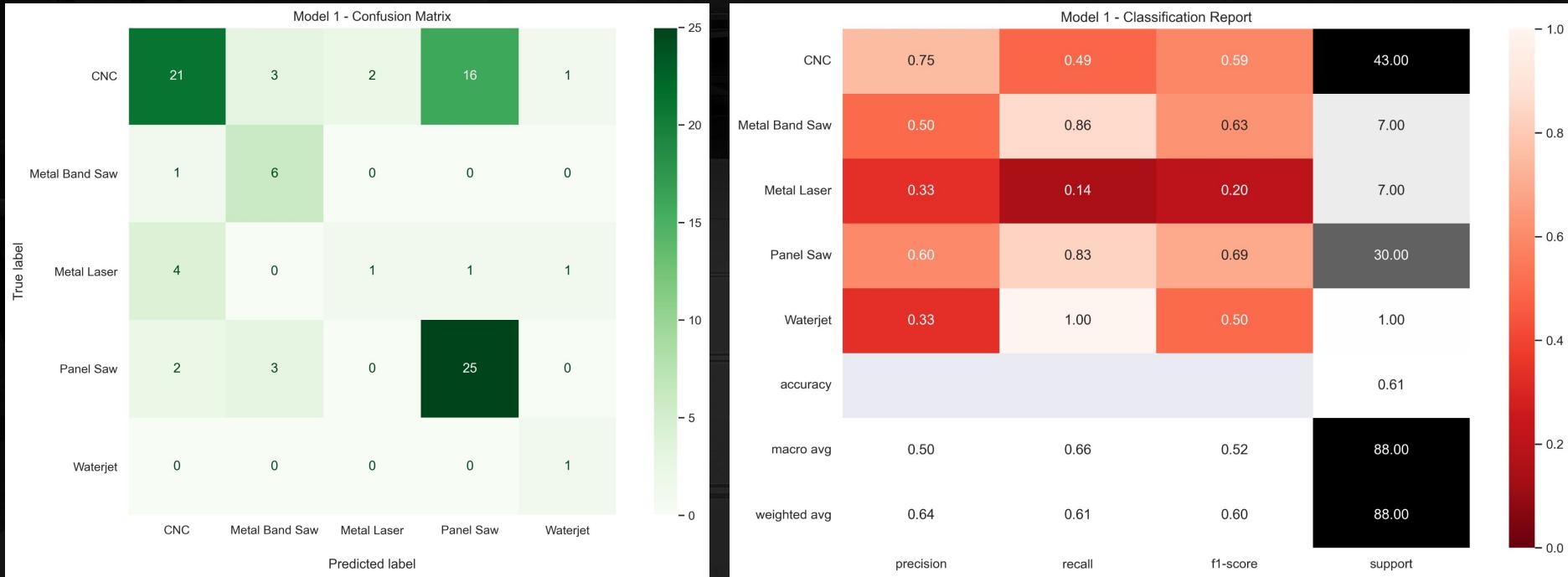


Loss improving over time



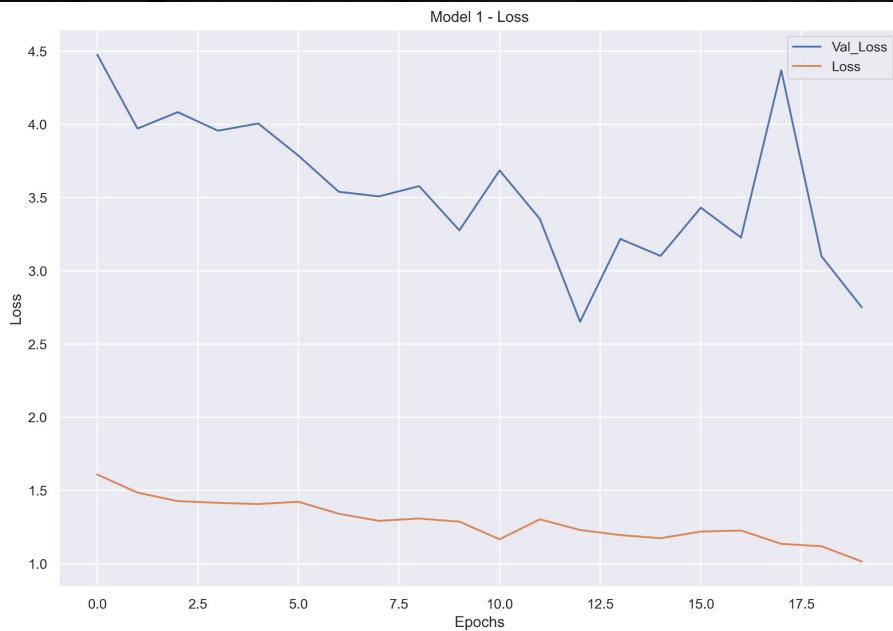
Accuracy improving over time

# Data - Model 1

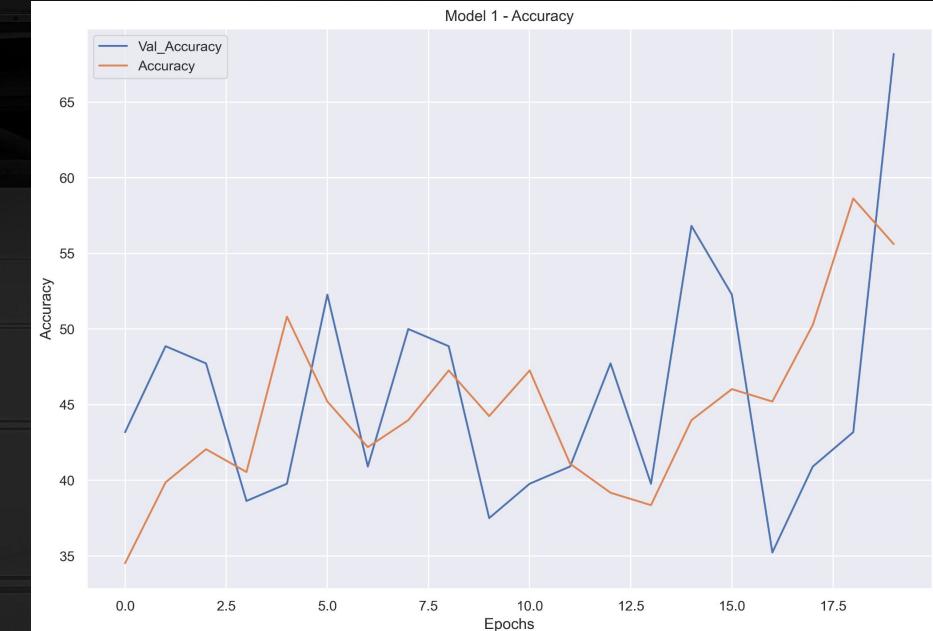


Values with data augmentation

# Data - Model 1

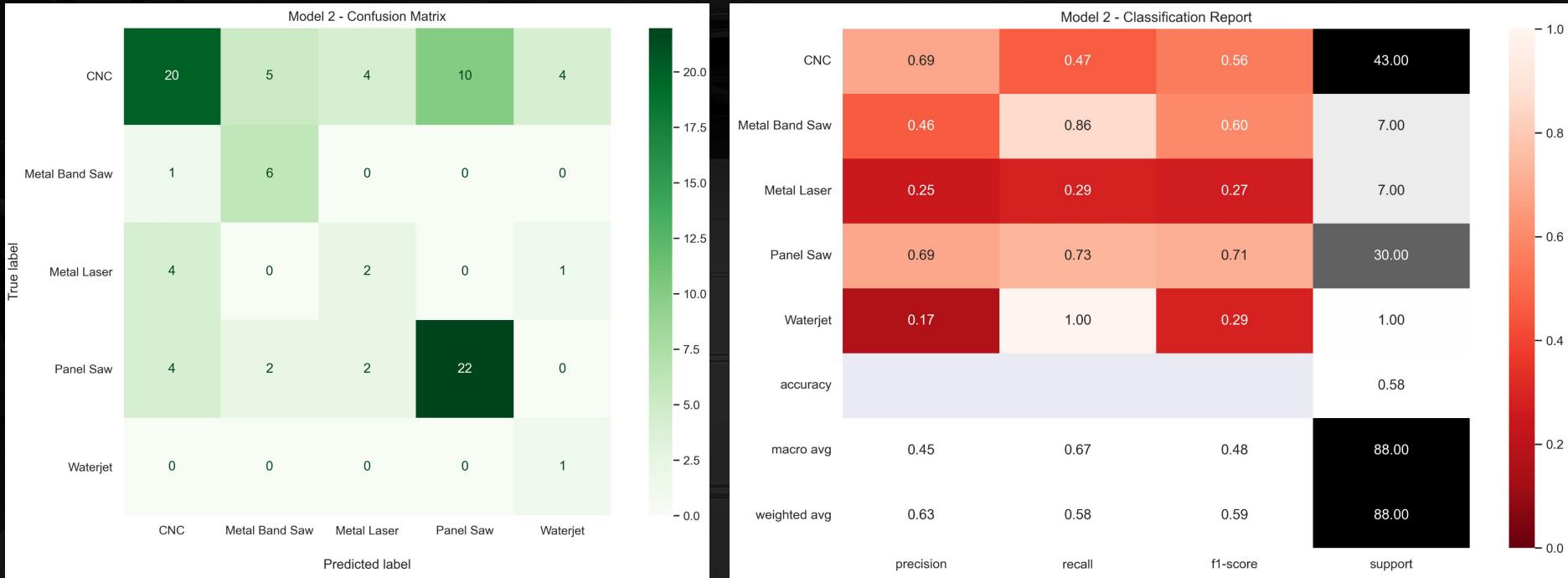


Loss improving over time



Accuracy improving over time

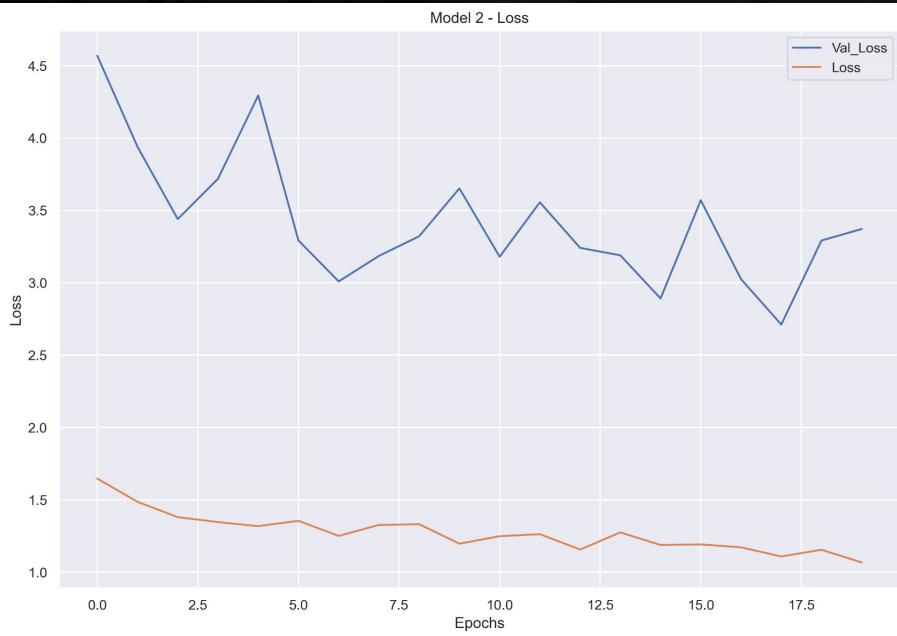
# Data - Model 2



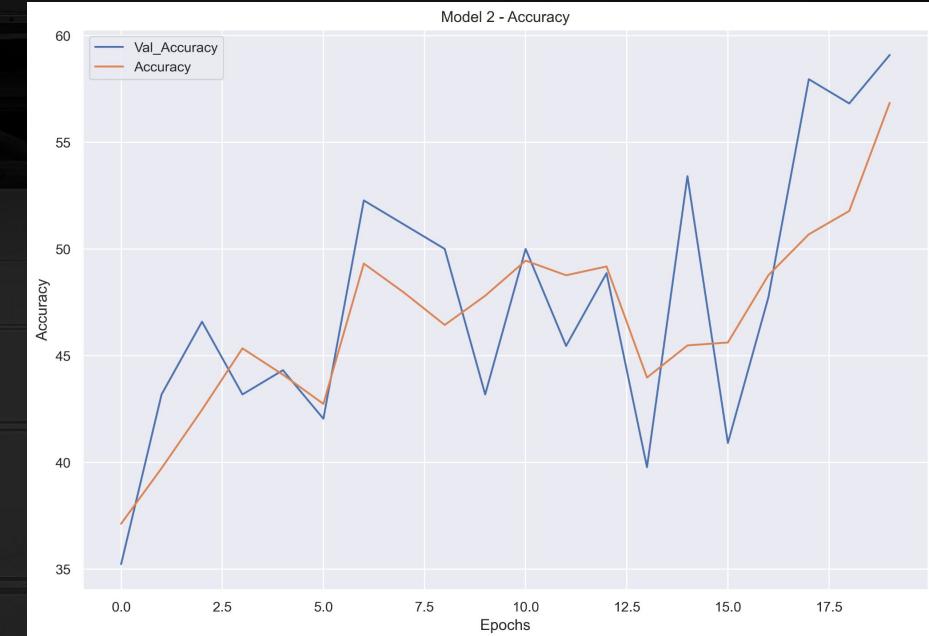
Values with data augmentation  
 Expand Channels for neural  
 network

# Data - Model 2

NORTHWOOD MACHINE MFG

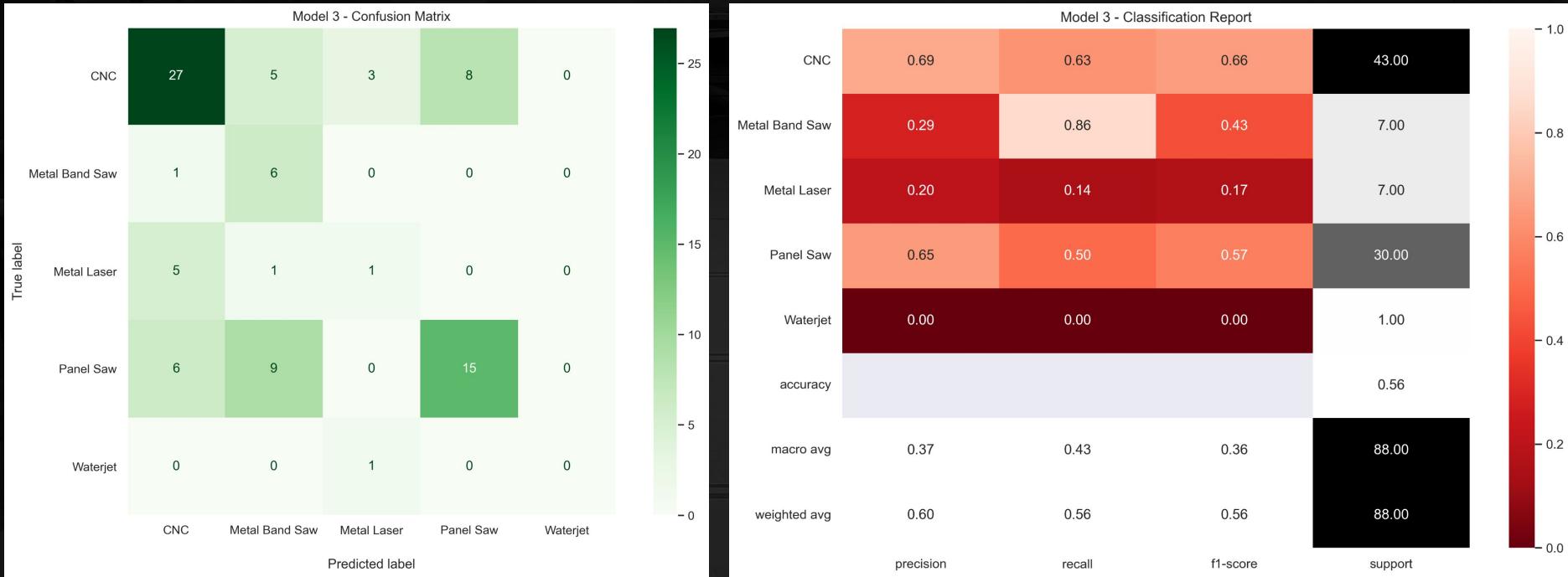


Loss slowly improving over time



Accuracy improving over time

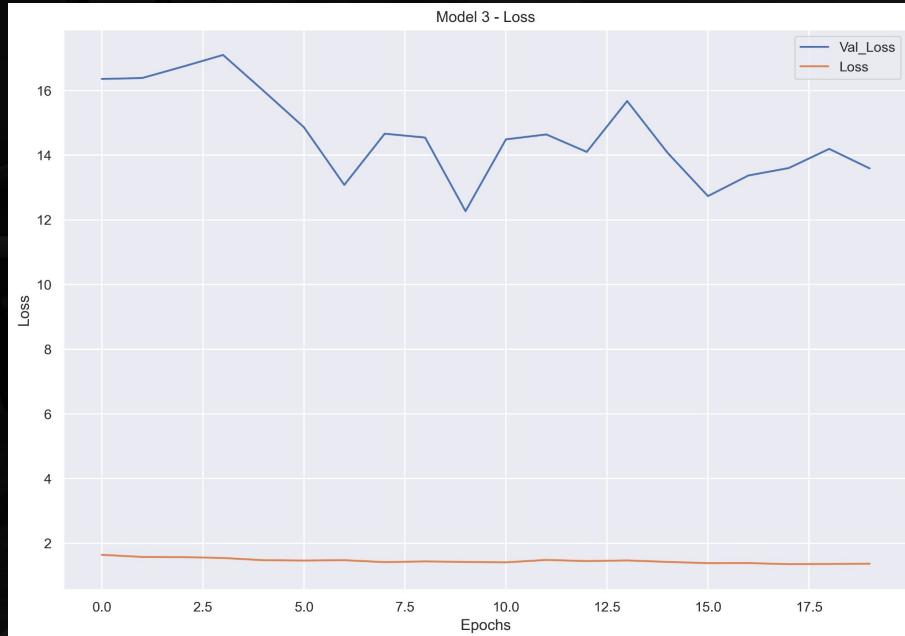
# Data - Model 3



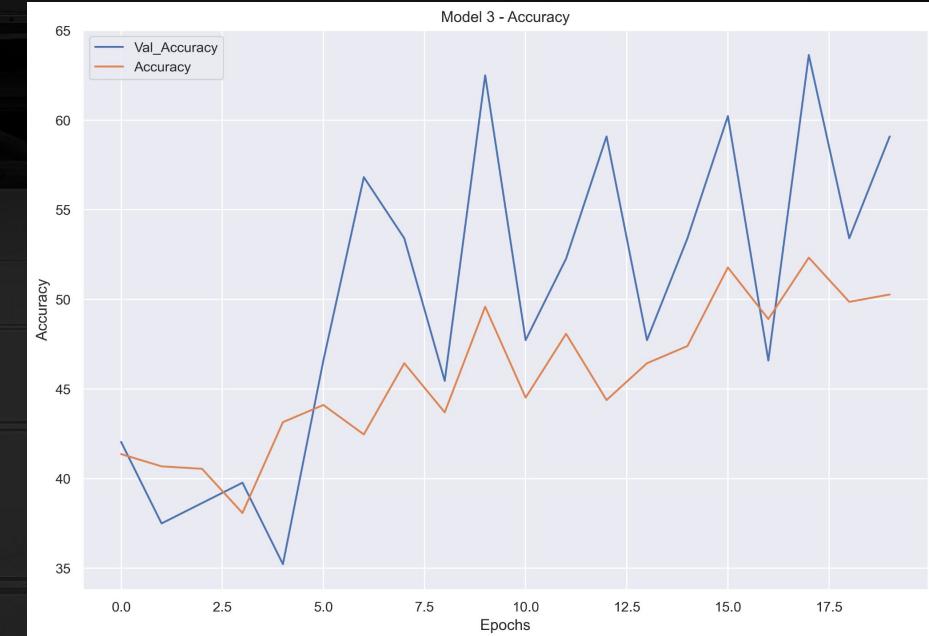
**Values with data augmentation  
Lower batch size and different  
optimizer**

# Data - Model 3

NORTHWOOD MACHINE MFG.

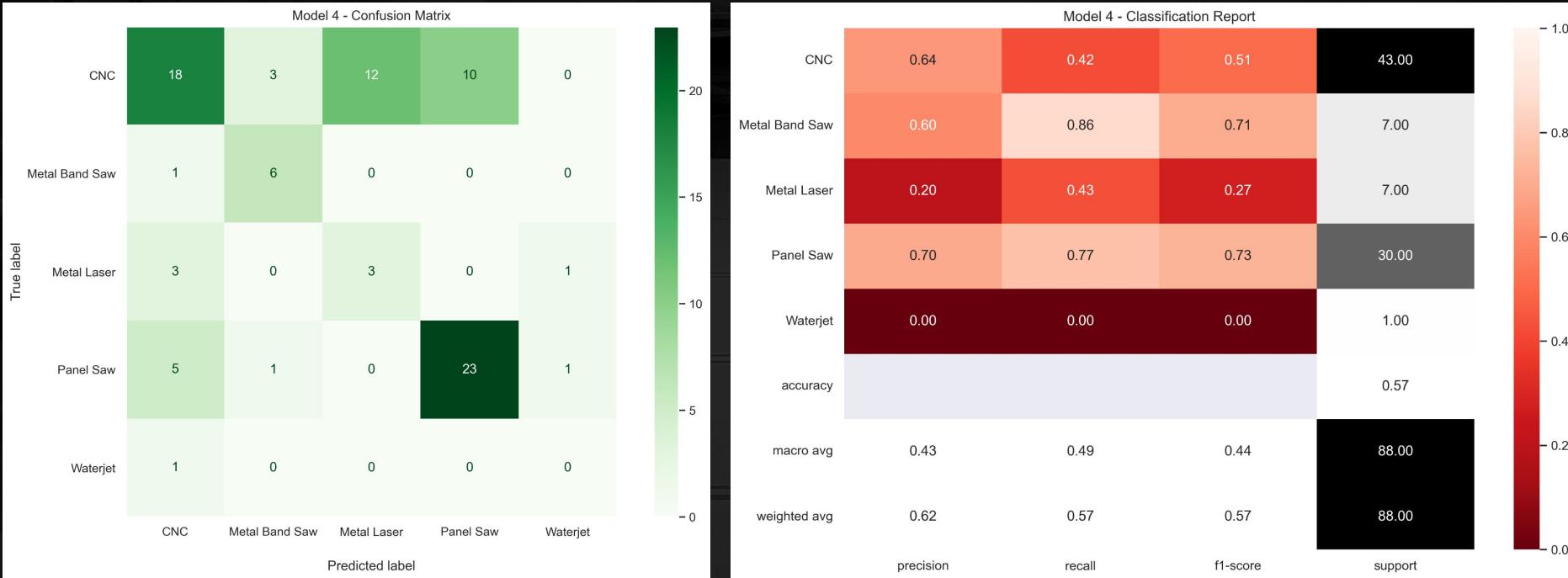


Loss stagnating



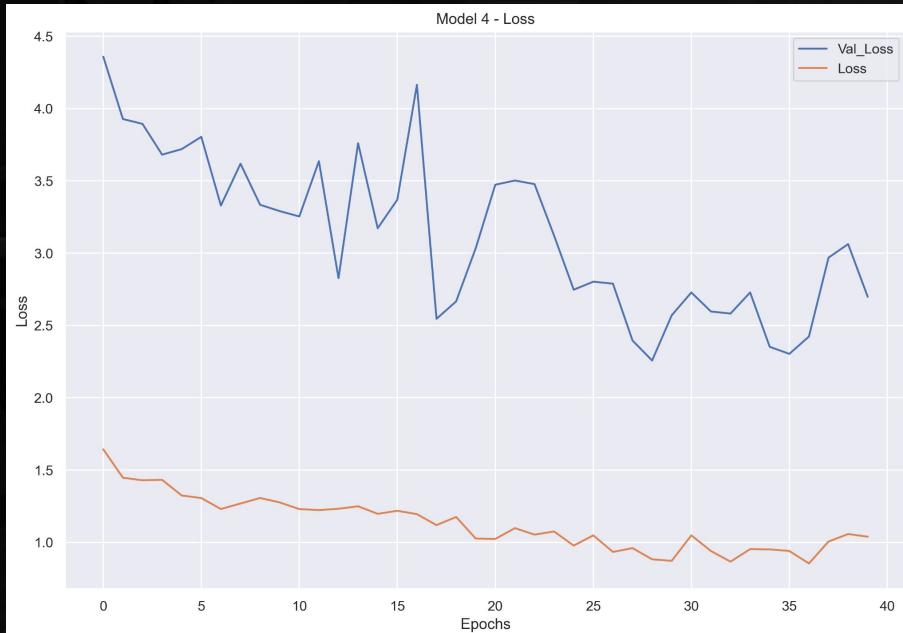
Accuracy erratic

# Data - Model 4

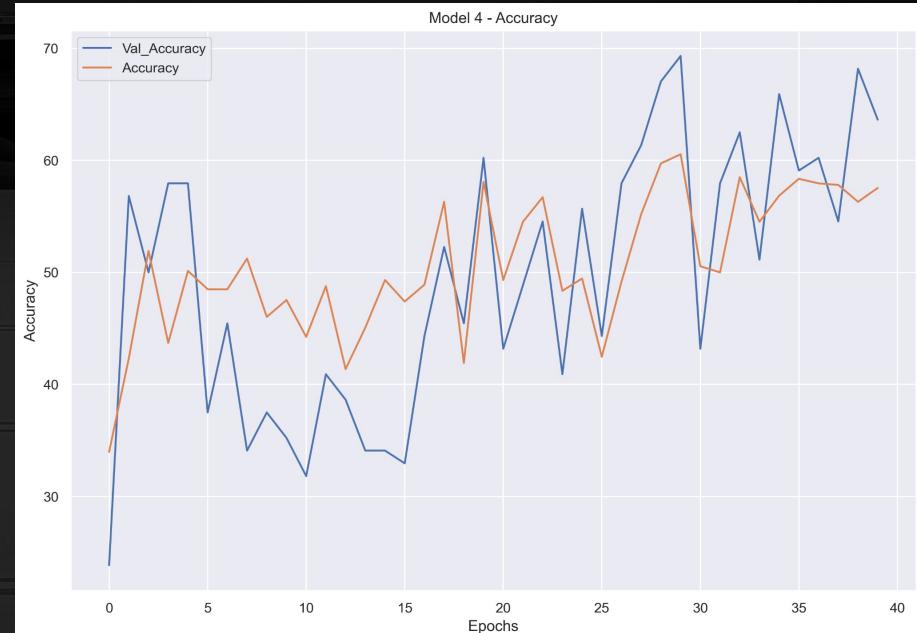


## Values with data augmentation Longer training improving on model 2

# Data - Model 4



Loss improving over time



Accuracy improving over time